

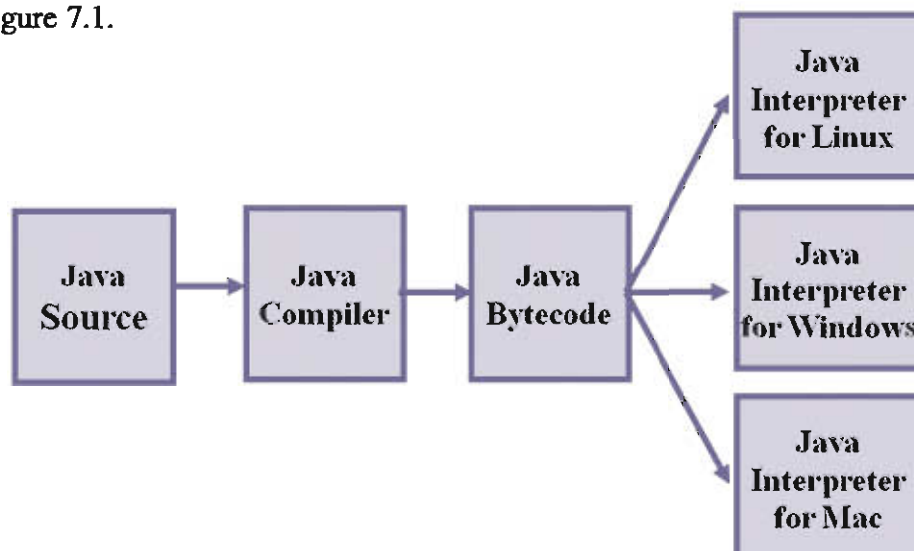
Java is an object-oriented programming language developed by Sun Microsystems, a company best known for its high-end Unix workstations. Modelled after C++, the Java language was designed to be small, simple, and portable across platforms and operating systems, both at the source and at the binary level. In this chapter, we will learn to start programming with Java. We will discuss simple Java statements, the basic things we can do in Java within a method `main()`. As we have already learnt C language, the basic constructs in Java will be very easy to understand. Most of the Java syntax is very similar to C language.

## Introduction to Java

Java language was developed at Sun Microsystems in 1991. Java is small, fast, efficient, and easily portable to a wide range of hardware devices. It is considered as one of the ideal language for distributing executable programs via the World Wide Web, and also a general-purpose programming language for developing programs that are easily usable and portable across different platforms.

Java is an object-oriented language and here it differs from C. Using Java, we can take full advantage of object oriented methodology and its capabilities of creating flexible, modular and reusable code. It includes a set of class libraries that provide basic data types, system input and output capabilities, and other utility functions. These basic classes are part of the Java Development Kit (JDK). JDK has classes to support networking, common Internet protocols and user interface toolkit functions. Because these class libraries are written in Java, they are portable across platforms as all Java applications are.

Java is platform-independent at both the source and the binary level. Platform-independence is a program's capability of being moved easily from one computer system to another. At the source level, Java's primitive data types have consistent sizes across all development platforms. At binary level, platform-independence is possible due to bytecode interpreter. The designers of Java chose to use a combination of compilation and interpretation. The scenario of platform independence is shown in figure 7.1.



**Figure 7.1 : Java : platform-independent**

Programs written in Java are compiled into machine language for a computer that doesn't really exist. This so-called "virtual" computer is known as the Java Virtual Machine (JVM). The machine language for the Java Virtual Machine is called Java bytecode. Different Java bytecode interpreter is needed for each type of computer. Java binary files are actually in a form called bytecodes that is not specific to any one processor or any operating system. The only disadvantage of using bytecodes is its slow execution speed. There are tools available to convert Java bytecodes into native code. Native code is faster to execute, but then it does not remain machine independent.

### Creating Simple Java Application

Before we learn the basics of Java programming language, let us begin exploring Java with a simple program that computes phone call charges and update the pre-paid balance amount. Here, we will learn how to create, compile and run Java programs.

A Java program is composed of classes. It should have at least one class and it must have main method in it. C programmers can think of a class as a sort of creating a new composite data type by using struct and typedef. Classes, however, can provide much more than just a collection of data. Note that typedef is not available in Java.

Let us give a name 'CallCost' to this Java application that computes call charges and update balance. To create and execute 'CallCost' application, we need to perform the following steps:

1. Create Java source file using any plain ASCII text editor.
  - Choose any text editor and type the program as given in code listing 7.1.
  - Save the source file with name 'CallCost.java'. Conventionally, Java source files are given the same name as the class they define, with an extension of .java. Note that the class name and filename are case sensitive. So, if class name is CallCost, filename should be CallCost.java (Applicable to SciTE editors).
2. Compile the source file using the Java compiler.
  - To compile the Java program, type javac followed by the name of your source file: `javac CallCost.java`
  - If the compiler show any errors, go back and make sure that you've typed the program exactly as it appears in code listing 7.1.
  - When the program gets compiled without errors, compiler creates a file with extension .class in the same directory as your source file. See that compiler has created file 'CallCost.class'. This is our Java bytecode file that will be executed.
3. Run the application using Java interpreter.
  - In the JDK, the Java interpreter is called simply using java. Type `java CallCost`.
  - To execute the program, we only need the compiled class file, not the source code.
  - Interpreter java uses the bytecode CallCost.class and executes it.

```

/**
 * This class implements a simple program that
 * will compute the cost of phone call and update balance
 */
public class CallCost
{
    public static void main(String[] args)
    {
        /* declare variables */
        double balance;      // balance amount in rupees
        double rate;          // call rate; rupees per second
        double duration;      // call duration in seconds
        double cost;          // cost of last call

        /* computations. */
        balance = 170;
        rate = 1.02;
        duration = 37;
        cost = duration * rate;          // compute the cost
        balance = balance - cost;        // update balance amount

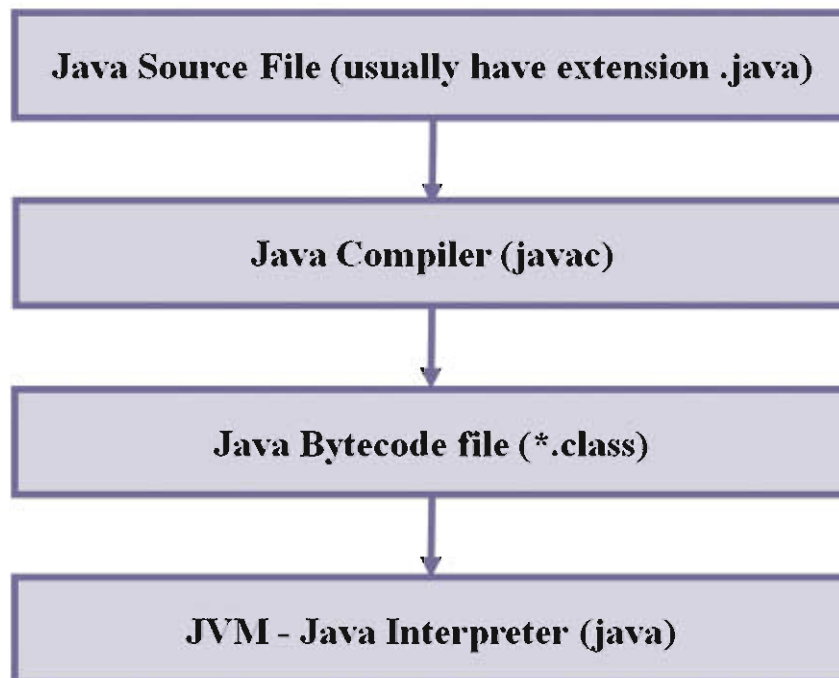
        /* display results */
        System.out.print("Call Duration: ");
        System.out.print(duration);
        System.out.println(" Seconds");
        System.out.println("Balance: " + balance + "Rupees ");

    } // end of main()
} // end of class CallCost

```

**Code Listing 7.1: Sample Java Program**

The process of compiling and executing a Java application is shown in figure 7.2.



**Figure 7.2 : Compilation Process**

Java source program file should have extension .java. It's name should be same as that of class when class is public. Note that the name is case sensitive. The compiler 'javac' compiles source file and creates Bytecode file. The name of bytecode file is same as the class name containing main method and it has an extension .class. An interpreter 'java' interprets bytecode and executes it.

Figure 7.3 shows how to compile and execute the program in linux environment using a terminal.

```
faculty3@faculty3: ~/Desktop/jrd
File Edit View Search Terminal Help
faculty3@faculty3:~/Desktop/jrd$ ls
CallCost.java
faculty3@faculty3:~/Desktop/jrd$ javac CallCost.java
faculty3@faculty3:~/Desktop/jrd$ ls
CallCost.class CallCost.java
faculty3@faculty3:~/Desktop/jrd$ java CallCost
Call Duration: 37.0 Seconds
Balance: 132.26Rupees
faculty3@faculty3:~/Desktop/jrd$
```

The screenshot shows a Linux terminal window with the title 'faculty3@faculty3: ~/Desktop/jrd'. The terminal displays the following commands and output: 'ls' shows 'CallCost.java'; 'javac CallCost.java' compiles the file; 'ls' shows 'CallCost.class' and 'CallCost.java'; 'java CallCost' runs the program, outputting 'Call Duration: 37.0 Seconds' and 'Balance: 132.26Rupees'.

**Figure 7.3 : Compilation and Execution of Java program in linux terminal**

Notice two main parts in code listing 7.1.

1. The program is enclosed in a class definition; here, a class called 'CallCost'.
2. The body of the program is contained in a routine called main(). In Java applications, main() is the first routine that is run when the program is executed.

### Explanation of Code Listing 7.1

The text written after `//` and enclosed within `/*` and `*/` are comments. As we know, comments are not compiled or interpreted.

- Variables are declared using data type followed by variable name.
- Computation part contains expressions including assignment statements.
- Here, several subroutine (also called function or method in Java) call statements are used to display information to the user of the program.
  - Methods used to display results : `System.out.print` and `System.out.println`. Both these methods take a value to be displayed as an argument.
  - Method `System.out.println` adds a linefeed after the end of the information that it displays, while `System.out.print` does not.
  - Call duration is displayed using three calls. First call displays label 'Call Duration:', second call displays the value of variable 'duration', third call displays label 'Seconds' and then bring the cursor in the next line. Note that string literal is enclosed in double quotes.
  - Balance is displayed using single call. Notice the use of `+` operator in Java in the parameter passed. It first evaluates the expression given as parameter and then display.

When we run the program, the Java interpreter calls the `main()` method and the statements that it contains are executed. These statements tell the computer exactly what to do when the program is executed. The `main()` routine can call other subroutines that are defined in the same class or even in other classes, but it is the `main()` routine that determines how and in what order the other subroutines are used.

The word "public" in the first line of `main()` means that this routine can be called from outside the program. This is essential because the `main()` routine is called by the Java interpreter, which is external to the program. The remainder of the first line of the routine is harder to explain at the moment; so for now, just think of it as part of the required syntax.

### Using SciTE

Let us create one more Java application using SciTE editor. Here our application will compute simple interest and display the results. Figure 7.4 shows the code listing and its output. Perform following steps :

- Start SciTE application. Select **File → New**.
- Type the Java program as per code listing given in figure 7.4 and save this source program in a file with name `Interest.java`. To save the file, select **File → Save** command.
- Compile source program using **Tools → Compile** command.
- If the program is compiled without any error, execute it using **Tools → Go** command.



```

Interest.java * SciTE
File Edit Search View Tools Options Language Buffers Help
1 Interest.java *
// compute simple interest

public class Interest
{
    public static void main(String[] args)
    {
        /* declare variables */
        double principal; // principal amount in rupees
        double rate; // interest rate in percentage
        double duration; // number of years
        double maturity; // maturity amount
        double interest; // interest amount

        /* computations. */
        principal = 17000;
        rate = 9.50;
        duration = 3;
        interest = principal * duration * rate / 100; // compute interest amount
        maturity = principal + interest; // compute maturity amount

        /* display results */
        System.out.println("Principal amount: " + principal + " Rupees");
        System.out.println("Deposit for duration of " + duration + " years");
        System.out.println("Interest Rate: " + rate + " %");
        System.out.println("Interest amount: " + interest + " Rupees");
        System.out.println("Maturity amount: " + maturity + " Rupees");
    } // end of main()
} // end of class Interest

> javac Interest.java
> Exit code: 0
> java -cp . Interest
Principal amount: 17000.0 Rupees
Deposit for duration of 3.0 years
Interest Rate: 9.5 %
Interest amount: 4845.0 Rupees
Maturity amount: 21845.0 Rupees
> Exit code: 0

```

**Figure 7.4 : Executing Java Program using SciTE**

### Structure of a Java program

Programming languages differ from ordinary human languages in being completely unambiguous and very strict about what is and is not allowed in a program. The rules that determine what is allowed are called the syntax of the language.

Syntax rules specify the basic vocabulary of the language and how programs can be constructed using things like variables, expressions, statements, branches, loops and methods. A syntactically correct program is one that can be successfully compiled or interpreted.

A structure of Java program is shown in figure 7.5. Here, text in angle bracket < and > is used as a placeholder that describes something actual we need to type while writing actual program. The definition of the method (function) in Java consists of function header and the sequence of statements enclosed between braces { and }.

As Java is an object-oriented language. Here, everything is defined as part of class. Thus, a method can't exist by itself. It has to be part of a class.

```

public class <class-name>
{
    <optional-variable-declarations-and-methods>
    public static void main(String[] args)
    {
        <statements>
    }
    <optional-variable-declarations-and-methods>
}

```

**Figure 7.5 : Structure of a Java Program**

- `<class-name>` in the first line is the name of the class having main method in it.

If the name of the class is `CallCost`, then the program should conventionally be saved in a Java source file with a name `CallCost.java`. When this file is compiled, another file named `CallCost.class` is generated. This class file is given a name using class name. Class file, `CallCost.class`, contains the translation of the program into Java bytecode, which can be executed by a Java interpreter.

- Variable and method declaration after and before `main()` method is optional.
- Each program must have one class that contains public method `main()`.
- Java is a free-format language. The layout (such as the use of blank lines and indentation) of the program in code listing 7.1 is not a part of the syntax or semantics of the language. The computer doesn't care about the program layout. We can write the entire program together on single line as far as it is concerned. However, layout is important to human readers.
- A program can contain other methods besides `main()`, as well as other variables. We will learn more about these later.

Now, let us start examining simple Java statements; the basic things we can do in Java within a method definition such as `main()`. We will learn the following with syntax :

- Data types
- Variables
- Literals
- Comments
- Java statements and expressions
- Arithmetic operators
- Comparisons
- Logical operators

## Data Types

Data type determines the required memory size, type of values, range of values and type of operations that can be performed. Java supports eight primitive data types that handle common types for integers, floating-point numbers, characters, and boolean values (true or false).

The primitive data types are named **byte, short, int, long, float, double, char, boolean**. The first four types hold integers (whole numbers such as 17, -38477, and 0), next two hold real numbers (such as 5.8, -129.35), `char` holds a single character from the Unicode character set and `boolean` holds one of the two logical values true or false.

These data types are called primitive as they are built into the system. Note that these data types are machine-independent, which means that we can rely on their sizes and characteristics to be consistent across all Java programs on all machines. Table 7.1 lists the details of data types.

Data Type	Storage Space	Type of Value	Range of Values	Default Value
byte	1 byte	Integer	-128 and 127	0
short	2 bytes	Integer	-32768 to 32767	0
int	4 bytes	Integer	-2147483648 to 2147483647	0
long	8 bytes	Integer	-9223372036854775808 to 9223372036854775807	0
float	4 bytes	Real	$10^{\pm 38}$ with about 7 significant digits	0
double	8 bytes	Real	$10^{\pm 308}$ with about 15 significant digits	0
char	2 bytes	Character	16-bit Unicode character	0
boolean	1 byte	Boolean	true, false	false

**Table 7.1 : Data Types in Java**

Integer numbers with  $b$  bits precision store signed values in the range of  $(-2^{b-1}, 2^{b-1})$ . When they are preceded with keyword unsigned, the values are in the range of  $(0, 2^{b-1})$ .

Real numbers in Java are compliant with IEEE 754 (an international standard for defining floating-point numbers and arithmetic). Java uses the Unicode character set. The char type has 16 bits of precision and is unsigned. This allows thousands of characters from many different languages and different alphabets to be used in Java. Data type boolean is not a number, nor can it be treated as one.

### Variable

If we want anything to be remembered by the computer during program execution, then it needs to be stored in the memory of a computer. Programs manipulate the data that are stored in memory. In machine language, data can only be referred to by giving the numerical address of the location in memory where it is stored. In a high-level language such as Java, names are used instead of numeric address of memory location to refer to data. The programmer has to remember only the name. A name used to refer to the data stored in memory is called a variable.

A variable can take different data values at different times during the execution of the program, but it always refers to the same memory location. A variable can be used in a java program only if it has first been declared.



One or more variables can be declared in Java using declaration statement with following syntax:

`<type-name> {variable-names};`

The conventions used here in the syntax are as follows:

- angle brackets `< >` denote the item to be specified by user
- curly brackets `{ }` denote the list of items separated by commas

Here `{variable-names}` denote the list of variable names. When the list contains more than one item, items should be separated by commas.

`<type-name>` is to be replaced with the keyword denoting the data type of the variables. It is used to determine the size of variable, the values it can hold and the operations that can be performed on it. When the computer executes a variable declaration statement, it sets aside memory for the variable and associates the variable's name with that memory.

Some examples of variables are as mentioned :

`int marks;`

`double amount, interest;`

`float rate;`

`char grade;`

`boolean isPass;`

To define variable name, we need to follow certain rules as mentioned :

- It must begin with an alphabet, underscore (`_`) or dollar sign (`$`). After first character, it may contain digits, alphabets, `$` and underscore.

Some legal names are: `birth_date`, `result`, `CallCost`, `top5students`, `date`, `amount$`, `$price`

Some illegal names are: `4me`, `%discount`, `birth date`

- No spaces are allowed in variables. Thus, `birth date` is invalid variable name.
- It cannot be a reserved word. Reserved words have special use in Java and cannot be used by the programmer for other purposes. Examples of some reserved words are `class`, `public`, `static`, `if`, `else` and `while`.

Guidelines for naming variables :

- Choose meaningful variable names. Java allows variable name of any length.
- When a name includes several words, such as 'balance amount', follow one of the conventions mentioned below :
  - Capitalize the first alphabet of each word, except for the first word. This is sometimes referred to as camel case, since the upper case letters in the middle of a name are supposed to look like the humps on a camel's back. Example: `balanceAmount`, `birthDate`

- Separate words with underscore. Example: balance\_amount, birth\_date
- Note that Java is case-sensitive. So, upper case and lower case letters are considered to be different. Thus, variable names balance and Balance are different.
- It is customary for names of classes to begin with upper case letters, while names of variables and of methods begin with lower case letters.

Good programming style for declaring variables :

- Declare only one variable in a declaration statement.
- Include a comment with each variable declaration to explain its purpose in the program.
- Declare important variables at the beginning of the function. Declare variables which are not important to the overall logic of the function at the point where they are first used.

In Java, there are three kinds of variables: instance variables, class variables, and local variables. Function parameters and variables declared in the function are considered as local variables. We will study about instance and class variables later.

We can also give each variable an initial value while declaring. For example,

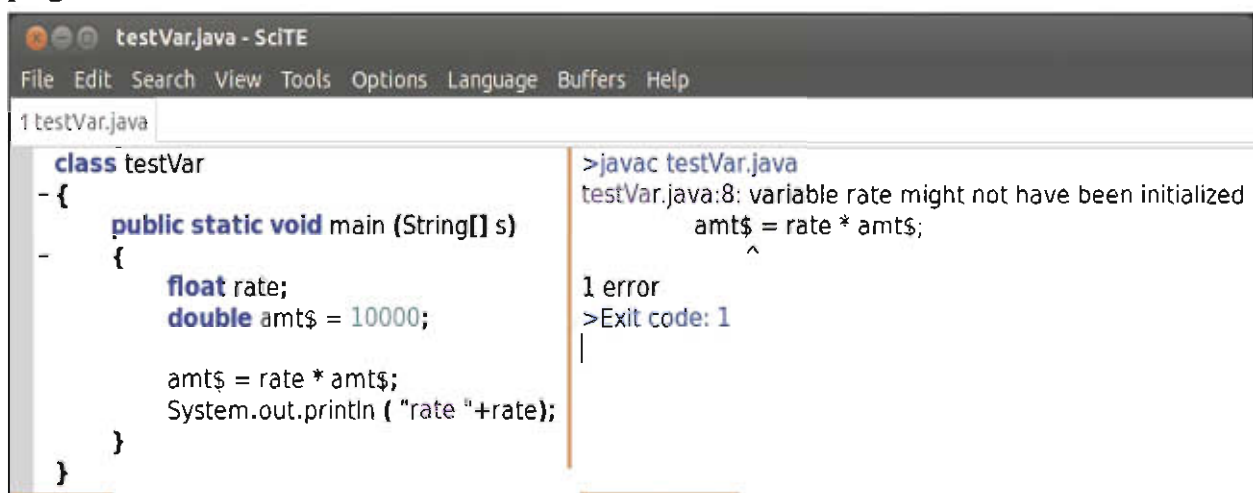
```
int marksObtained, totalMarks=100, counter=0;

boolean isPass = true;
```

In general, syntax of declaring variables is as follows: <type name> {variable [= <value>],};

Here items in square bracket [ ] denotes optional item.

Note that local variables are not initialized with default values. It is programmer's responsibility to assign value to such variables before their first use. Figure 7.6 shows the use of variable in java program.



```
class testVar
- {
    public static void main (String[] s)
    - {
        float rate;
        double amt$ = 10000;

        amt$ = rate * amt$;
        System.out.println ( "rate "+rate);
    }
}
```

```
> javac testVar.java
testVar.java:8: variable rate might not have been initialized
    amt$ = rate * amt$;
            ^
1 error
> Exit code: 1
```

**Figure 7.6 : Local Variables in Java**

Observe that the local variable 'rate' is not assigned any value before its use in statement 'amt\$ = rate \* amt\$'. When we try to compile the program the compiler will give an error as can be seen in figure 7.6.

## Literals

A name used for a constant value is known as literal. There are some different kinds of literals in Java for number, character, string and boolean values.

### Numeric Literals

Numeric literals are used to represent integer or real numbers for example, 157 and 17.42 are literals.

**Integer literals** are literals that are whole numbers. Java allows decimal (base 10), octal (base-8) and hexadecimal (base-16) and Unicode integer literals.

Ordinary integers such as 4, 157, 17777 and -32 are decimal integer literals of type byte, short or int depending on their size. A decimal integer literal larger than int is automatically of type long. We can force a smaller number to be a long by appending an L or l (upper or lower case letter l) as a suffix to that number (for example, 4L is a long integer having value 4). Negative integers are preceded by a minus (-) sign, for example, -45.

Octal numbers use only the digits 0 through 7. In Java, a numeric literal with a leading 0 (zero) is interpreted as an octal number. For example, literal 045 represents octal integer whose decimal number value is 37.

Hexadecimal numbers use 16 digits, the usual digits 0 through 9 and the letters A, B, C, D, E, and F. Upper case and lower case letters can be used interchangeably in this context. The letters A to F represent the numbers 10 to 15 respectively. In Java, a hexadecimal literal begins with 0x or 0X. Examples of hexadecimal literals are 0x45 or 0xFF7A. Hexadecimal numbers are also used in character literals to represent arbitrary Unicode characters.

A Unicode literal consists of \u followed by four hexadecimal digits. For example, the character literal '\u00E9' represents the Unicode character that is an "e" with an acute accent.

Java 7 also supports binary numbers, using the digits 0 and 1 and the prefix 0b (or 0B). For example: 0b10110 or 0b101011001011.

**Real number literals** are called floating point literals. These numbers can be represented using two types of notations: standard and scientific.

In standard notations, the integer part and the fractional part are separated with decimal point (.), for example 12.37.

In scientific notation, a number is followed by letter e (or E) and a signed integer exponent, for example 1.3e12 and 12.3737e-108. The "e12" and "e-108" represent powers of 10. Hence 1.3e12 means 1.3 times  $10^{12}$  and 12.3737e-108 means 12.3737 times  $10^{-108}$ . Scientific format can be used to express very large and very small numbers.

In Java, floating point literal by default is of the type double. To make a literal of type float, we have to append an "F" or "f" as a suffix to the number. For example, "1.2F" specifies literal 1.2 to be considered as a value of type float.

```

class testVar
{
    public static void main (String[] s)
    {
        float rate = 10.2;
        double amt$ = 10000;

        amt$ = rate * amt$;
        System.out.println ( "rate "+rate);
    }
}

```

```

>javac testVar.java
testVar.java:5: possible loss of precision
found   : double
required: float
        float rate = 10.2;
                        ^
1 error
>Exit code: 1

```

**Figure 7.7 : Compilation error**

Observe that in figure 7.7 we get a compilation error as we have assigned a literal 10.2 to variable of float type. To make the program work we have to write this statement as "float rate = 10.2f;". The suffix F can be written in either lower or upper case.

### Boolean literals

For the type boolean, there are precisely two literals: true and false. These literals are to be typed without quotes. They represent values, not variables. Boolean values occur most often as the values of conditional expressions. In C, 0 is treated as false and non-zero value is treated as true. In Java, literals true and false are not associated with any numeric value.

### Character literals

Character literals are expressed by a single character surrounded by single quotes: 'a', '#', '3' and so on. Characters are stored as 16-bit Unicode characters. Certain special characters have special literals that use a backslash (\) as an "escape character". Table 7.2 lists the special codes that can represent nonprintable characters, as well as characters from the Unicode character set.

Escape code	Meaning
\n	New line
\t	Tab
\b	Backspace
\r	Carriage return
\f	Form feed (New page)
\\	Back slash character
\'	Single quote character
\"	Double quote character
\ddd	Character represented by three octal digits ( d: 0 to 7)
\xdd	Character represented by two hexadecimal digits (d: 0 to 9, a to f)
\udddd	Character represented by Unicode number dddd (d: hexadecimal digit)

**Table 7.2 : Escape Codes**



## String literals

In Java all the other data types represent objects rather than "primitive" data. We are not concerned with objects for the time being. However, we will consider here one predefined object type that is very important: the type String. A String is a sequence of characters.

In code listing 7.1, we have used a string literal: "Balance:". String literal is a sequence of characters enclosed in double quotes. Within a string, special characters can be represented using the backslash notation as given in Table 7.2.

For example, to represent the string value: Many "Congratulations!", we need to type string literal: "Many, \"Congratulations!\""

Similarly in string "This string brought to you by Java\u2122", the Unicode code sequence \u2122 produces a trademark symbol (™).

## Comments

Comments in a program are for human readers only; they are entirely ignored by the computer. Comments are important to make the program easy to understand for everyone.

Java supports following types of comments :

- **Single-line comment:** It begins with double slashes (//) and extends till the end of a line. The computer ignores the // and everything that follows it on the same line.
- **Multi-line comment:** It begins with /\* and ends with \*/. This type of comment is usually used to have more than one line as comments. Actually, one may embed phrase as well as one or more entire lines as comments between /\* and \*/. Any text between two delimiters /\* and \*/ is considered as a comment. Comments cannot be nested; that is, we cannot have a comment inside a comment.
- **Documentation comment:** These type of comments begin with /\*\* and end with \*/. They are used for creating API documentation from the code. These are special comments that are used for the javadoc system. Discussion of javadoc is out of scope of this book.

Other than comments, everything else in the program is required to follow the rules of Java syntax.

## Expressions

Expressions are an essential part of programming. The basic building blocks of expressions are literals (such as 674, 3.14, true, and 'X'), variables, and function calls. Recall that a function is a subroutine that returns a value.

Simple expression can be a literal, a variable, a function call. More complex expressions can be built up by using operators to combine simpler expressions.

Operators include arithmetic operators (+, -, \*, /, %), comparison operators (<, >, =, ...), logical operators (and, or, not...). When several operators appear in an expression, there is a question of precedence, which determines how the operators are grouped for evaluation. For example, in the expression "A + B \* C", B\*C is computed first and then the result is added to A. We say that multiplication (\*) has higher precedence than addition (+). If the default precedence is not what

we want, we can use parentheses to explicitly specify the grouping. For example, in expression "(A + B) \* C", it adds A and B first then multiplies the result by C.

## Operators

Operators are special symbols used to build an expression. Java supports many types of different operators. In this chapter, we will discuss the following operators :

- Arithmetic operators
- Comparison operators
- Logical operators
- Conditional operator
- Assignment operator

### Arithmetic operators

In Java, basic arithmetic operators are addition (+), subtraction (-), multiplication (\*), division (/) and modulus (%). All these operators are binary, they take two operands. Operators + and - can be used as unary (taking only one operand) also. All operators can be applied on any type of numeric data: byte, short, int, long, float, or double. They can also be used with values of type char, which are treated as integers in this context. With char type of data, its Unicode code number is considered as its value when it is used with an arithmetic operator. Arithmetic operators are described in table 7.3.

Operator	Meaning	Example	Result
+	Addition	2 + 8	10
-	Subtraction	2 - 8	-6
*	Multiplication	2 * 8	16
/	Division	8 / 2	4
%	Modulus (Gives remainder after division where quotient is an integer value)	8 % 3 25.8 % 7	2 4.8

**Table 7.3 : Arithmetic operators**

Data type of the result after binary arithmetic operation :

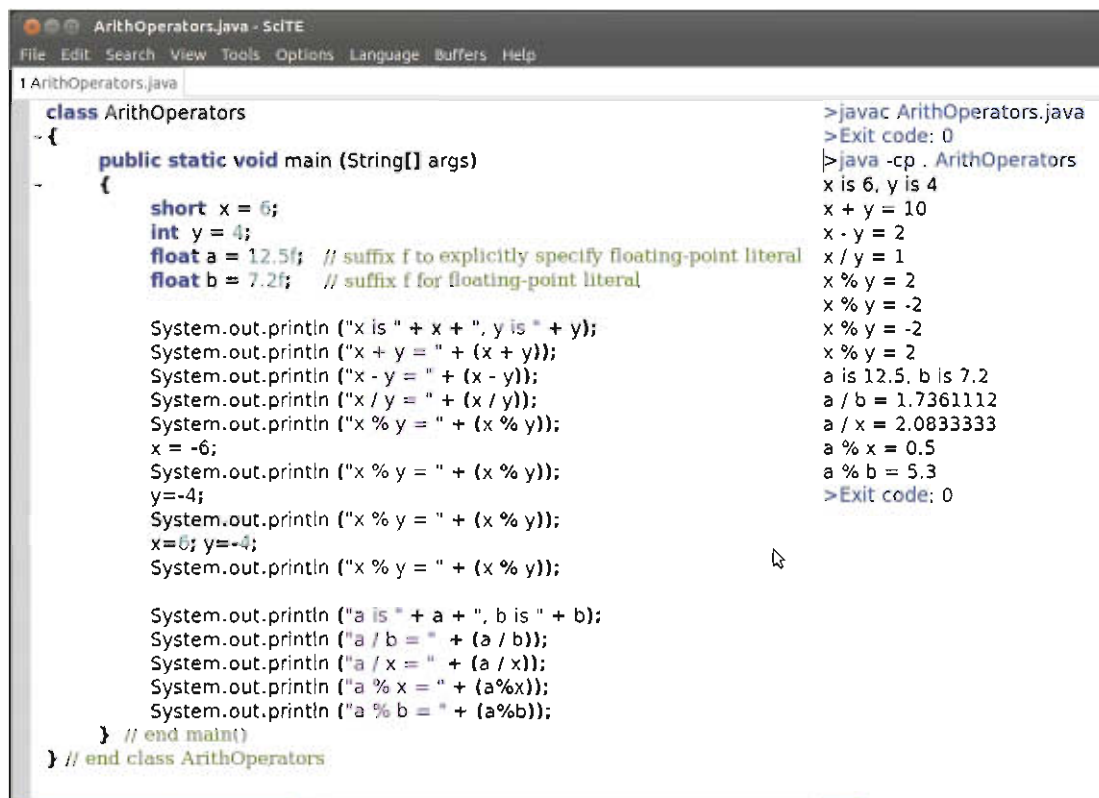
- When both operands are of same data type, the data type of the result is same as the type of operands.
  - If both operands are integers, result is an integer. For example, result of 9/2 is 4 and not 4.5. Integer division results into integer value and remainder is discarded.
  - If both operands are float, result is float. Example : 9f/2f results in 4.5.

- When both operands are of different data types,
  - First of all, lower range data type is implicitly converted to higher data type to have the same types of operands. This type of conversion is also known as promotion.
  - Now, the result of an expression will be same as higher range operand.
  - Example:  $4 + 3.5$  results in 7.5,  $9/2.0$  results in 4.5,  $9f/2$  results in 4.5.

#### Points to remember :

- With modulus operator %, if first operand is negative, the result is negative.
- In Java, % operator can be used with floating point data types also. The result is the remainder after integer quotient. Thus for  $25.8 \% 7$ , integer quotient is 3 and remainder is  $25.8 - (3 \times 7) = 4.8$ .
- Operator + can also be used to concatenate a string.

When operator + is applied with one of the operand of type String, other operand is automatically converted into type String. This is also an example of implicit type conversion. This type of conversion is seen in code listing 7.1 in an expression 'Balance: ' + balance ' while printing balance amount. It is also used in code listing shown in figure 7.8.



```

class ArithOperators
{
    public static void main (String[] args)
    {
        short x = 6;
        int y = 4;
        float a = 12.5f; // suffix f to explicitly specify floating-point literal
        float b = 7.2f; // suffix f for floating-point literal

        System.out.println ("x is " + x + ", y is " + y);
        System.out.println ("x + y = " + (x + y));
        System.out.println ("x - y = " + (x - y));
        System.out.println ("x / y = " + (x / y));
        System.out.println ("x % y = " + (x % y));
        x = -6;
        System.out.println ("x % y = " + (x % y));
        y = -4;
        System.out.println ("x % y = " + (x % y));
        x = 6; y = -4;
        System.out.println ("x % y = " + (x % y));

        System.out.println ("a is " + a + ", b is " + b);
        System.out.println ("a / b = " + (a / b));
        System.out.println ("a / x = " + (a / x));
        System.out.println ("a % x = " + (a % x));
        System.out.println ("a % b = " + (a % b));
    } // end main()
} // end class ArithOperators
  
```

```

> javac ArithOperators.java
> Exit code: 0
> java -cp . ArithOperators
x is 6, y is 4
x + y = 10
x - y = 2
x / y = 1
x % y = 2
x % y = -2
x % y = -2
x % y = 2
a is 12.5, b is 7.2
a / b = 1.7361112
a / x = 2.0833333
a % x = 0.5
a % b = 5.3
> Exit code: 0
  
```

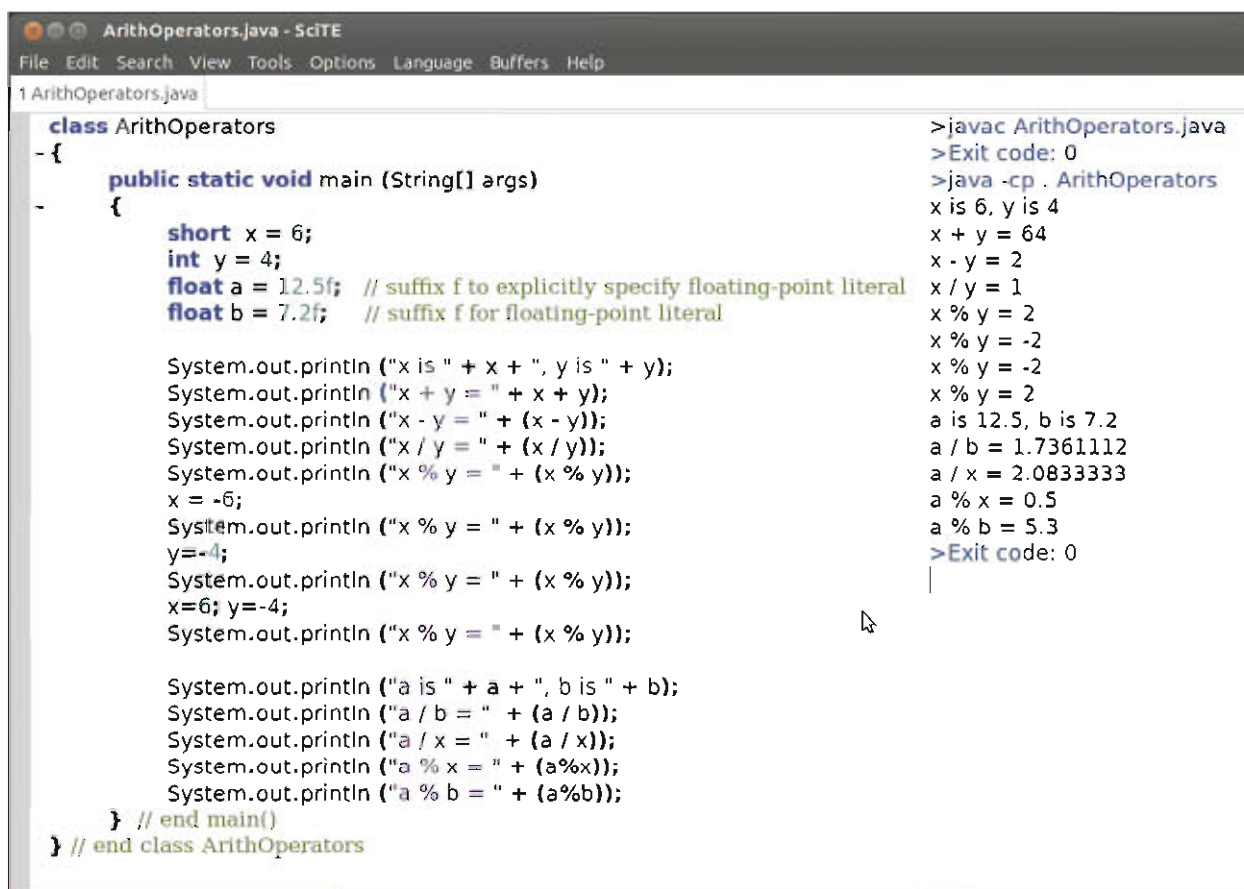
**Figure 7.8 : Java program showing use of arithmetic operators**

#### Explanation of program shown in figure 7.8 :

- We initially define four variables in main() method: x and y, which are integers (type short and int); a and b, which are floating point real numbers (type float).

- Remember that default type for floating-point literals (such as 12.5) is double. So, f is suffixed with literals 12.5 and 7 to treat them as float type.
- The `System.out.println()` method merely prints a message to the standard output device. This method takes a single argument, a string, but we can use `+` to concatenate values into a string. As pointed before, Java converts numbers into string and then concatenates the two.
- The result of `x%y` is 2 when `x=6` and `y=-4` because first operand is positive.
- The result of `a%x` is 0.5 where `a=12.5` and `x` is 6. Here, integer quotient is 2 and the remainder is 0.5. Similarly in case of `a%b` where `a=12.5` and `b=7.2`; the integer quotient is 1 and the remainder is 5.3.
- See the mixed type of operands in the call: `System.out.println ("a / x = " + (a / x));`. Here variable `a` is float and `x` is int, the result after division is float. While evaluating an expression, values are promoted to the higher data type operand.

Experiment with the same program after removing parenthesis of expression `x+y` in 2nd call of `System.out.println` method (i.e. in line 11 of code listing in figure 7.8, replace an expression `"x + y = " + (x + y)` with an expression `"x + y = " + x + y`) and analyse the results shown in figure 7.9.



```

class ArithOperators
- {
    public static void main (String[] args)
    {
        short x = 6;
        int y = 4;
        float a = 12.5f; // suffix f to explicitly specify floating-point literal
        float b = 7.2f; // suffix f for floating-point literal

        System.out.println ("x is " + x + ", y is " + y);
        System.out.println ("x + y = " + x + y);
        System.out.println ("x - y = " + (x - y));
        System.out.println ("x / y = " + (x / y));
        System.out.println ("x % y = " + (x % y));
        x = -6;
        System.out.println ("x % y = " + (x % y));
        y=-4;
        System.out.println ("x % y = " + (x % y));
        x=6; y=-4;
        System.out.println ("x % y = " + (x % y));

        System.out.println ("a is " + a + ", b is " + b);
        System.out.println ("a / b = " + (a / b));
        System.out.println ("a / x = " + (a / x));
        System.out.println ("a % x = " + (a%x));
        System.out.println ("a % b = " + (a%b));
    } // end main()
} // end class ArithOperators
  
```

```

>javac ArithOperators.java
>Exit code: 0
>java -cp . ArithOperators
x is 6, y is 4
x + y = 64
x - y = 2
x / y = 1
x % y = 2
x % y = -2
x % y = -2
x % y = 2
a is 12.5, b is 7.2
a / b = 1.7361112
a / x = 2.0833333
a % x = 0.5
a % b = 5.3
>Exit code: 0
  
```

**Figure 7.9 : Effect of removing ( ) from (x+y) in line 11 of code listing in figure 7.8**

## Increment and Decrement operators

Unary operators `++` and `--` are called the increment operator and the decrement operator respectively. Operator `++` adds 1 to a variable and `--` subtracts 1 from the variable.



These operators can be used on variables belonging to any of the integer types and also on variables of type char. If `x` is an integer variable, we can use `x++`, `++x`, `x--`, `--x` as expressions, or as parts of larger expressions.

When `++` or `--` operator is used after variable name, it is known as post-increment or post-decrement operator. The old value of variable is used while evaluating the expression and thereafter the value of variable is incremented or decremented. For example, let the value of variable `x` be 3 before executing statement `y = 4 + x++`; Here old value of `x` is used while evaluating expression on right-hand side and thereafter `x` is incremented. As a result, value of `x` will be 4 and `y` will be 7.

When `++` or `--` operator is used before variable name, it is known as pre-increment or pre-decrement operator. Here the value of variable is incremented or decremented first and then this new value is used in expression. For example, in statement `y = 4 + ++x`; if old value of `x` is 3, then value of `x` is incremented first and then this new value is used in evaluating an right-hand side expression. So value of `x` will be 4 and that of `y` will be 8.

When this operator is used in a standalone statement, use of pre or post does not make any difference. For example, statements `x++`; and `++x`; are standalone statements.

### Comparison operators

Comparison operators are also known as relational operators. The comparison operators in Java are: `==`, `!=`, `<`, `>`, `<=`, and `>=`. The meanings of these operators are:

<code>A == B</code>	Is A "equal to" B ?
<code>A != B</code>	Is A "not equal to" B ?
<code>A &lt; B</code>	Is A "less than" B ?
<code>A &gt; B</code>	Is A "greater than" B ?
<code>A &lt;= B</code>	Is A "less than or equal to" B ?
<code>A &gt;= B</code>	Is A "greater than or equal to" B ?

These operators can be used to compare values of any of the numeric types as well as of char type. For characters, their unicode numeric values are used in comparison.

After applying comparison operator, the result of expression is boolean; either true or false. So, such expressions are also called boolean-valued expression.

We can also assign boolean-valued expressions to boolean variables, just as assigning numeric values to numeric variables.

Operators `==` and `!=` can also be used to compare boolean values. For example :

```
boolean bothPositive; bothPositive = ((x > 0) == (y > 0));
```

Usually, relational operators are used in if statements and loops.

### Logical operators

Logical operators are also called boolean operators, as they operate on Boolean operands. In Java,

logical operations AND, OR, XOR and NOT are performed using operators `&&`, `||`, `^` and `!` respectively.

Boolean operator `&&` is used to combine two boolean values for logical AND operation. The result of expression `A && B` is true only if both the operands A and B are true. For example, `(x == 0) && (y == 0)` is true if and only if both x is equal to 0 and y is equal to 0.

Boolean operator for logical OR is `||` (two vertical line characters). Expression `A || B` is true if either A is true or B is true, or if both are true. The result is false only if both A and B are false. For example, `(x == 0) && (y == 0)` is false only if both x and y are not equal to 0.

Boolean operator for logical NOT is denoted by `!` and it is a unary operator. It results in complemented result. If the operand is true, result is false and vice versa.

In addition, there is operator `^` to perform logical XOR (exclusive OR). It returns true only if its operands are different (one true and one false) and false otherwise. Thus result is false when both operands have same boolean value. For example, `(x == 0) ^ (y == 0)` is true if only one of the x or y is zero.

### Short circuiting

When using the conditional AND and OR operators (`&&` and `||`), Java does not evaluate the second operand unless it is necessary to resolve the result. If first operand is false in case of `&&`, there is no need to evaluate second operand. Similarly, if first operand is true in `||`, there is no need to evaluate second operand.

For example, consider expression `(x != 0) && (y/x > 1)`. If the value of x is zero, first sub-expression `(x != 0)` results in false. As logical operator `&&` results in false when any one of the operands is false, there is no need to evaluate second sub-expression `(y/x > 1)`. Here, the evaluation has been short-circuited and the division by zero is avoided. Without the short-circuiting, there would have been a 'division by zero' error at runtime.

### Conditional operator

The conditional operator in Java is a ternary operator using three operands. It uses two symbols `?` and `:` in the expression to delimit three operands. It takes the following form:

*<boolean-expression> ? <expression1> : <expression2>*

Here, the first operand is a boolean expression and is evaluated first. If its value is true, value of the entire expression is the value of second operand expression1; otherwise it evaluates to third operand expression2.

For example, consider statement: `next = (N % 2 == 0) ? (N/2) : (3*N+1);`

Suppose value of N is 8. The value of first operand `(N % 2 == 0)` is true, so value of right-hand side expression is the value of expression `(N/2)`, i.e. 4. If N is odd, first expression results in false and it will assign the value `(3*N+1)` to next. Note that the parentheses in this example are not required, but they do make the expression easier to read.

## Assignment

In Java, an expression containing assignment (=) operator is generally referred to as assignment statement.

Once a variable has been declared, we can assign a value to that variable by using the assignment operator '='. In Java, one of the ways to get data into a variable is with an assignment statement. An assignment statement takes the form :

`< variable > = < expression >;`

where <expression> represents anything that refers to or computes a data value.

When an assignment statement is executed, it first evaluates the expression on right side of = sign and then put the resulting data value into the variable on left side of = sign.

For example, consider the simple assignment statement: `rate = 10.02f;`

Here the variable in this assignment statement is 'rate', and the expression is the number '10.02f'. Execution of this statement replaces the value of float variable 'rate' by 10.02.

Now, consider another assignment statement: `balance = balance - cost;`

Here expression 'balance-cost' is evaluated first using the existing values of variables 'balance' and 'cost' in memory. There after the resulting value is placed in variable 'balance' replacing its older value.

When a variable is used in an expression on right-hand side, it refers to the value stored in the variable. When a variable is used on the left-hand side of an assignment statement, it refers to memory location that is named by the variable to place the value. So, variable on left-hand side of expression is called lvalue, referring to location in memory.

In general, the type of the expression on the right-hand side of an assignment statement should be the same as the type of the variable on the left-hand side. However, if they are not matching, the value of expression is automatically converted to match the type of the variable. If the data type of expression is larger than the variable on left-hand side, it may result in an error due to precision problem. For example, there may not be automatic conversion from int to short or double to float.

## Shorthand assignment operators

Java also support shorthand version of assignment. It saves the typing time. It takes the form `<variable> <operator> = <expression>`. Its effect is same as `<variable> = <variable> <operator> <expression>`. Here the operator should be a binary operator using two operands.

Some examples of shorthand assignment operators are; `a += b` and `q &&= p`. Here `a += b` is same as `a = a + b`, while expression `q &&= p` is same as expression `q = q && p`.

## Type cast

In some cases, we may want to force a conversion that wouldn't be done automatically. For this, we can use what is called a type cast. A type cast is indicated by putting a type name in parentheses before the value we want to convert. Thus it takes a form :

`(<data-type>) <expression>`

For example,

```
int a; short b;
```

```
a = 17; b = (short)a;
```

Here variable a is explicitly converted using type cast to a value of type short

### Precedence and associativity of Java operators

Java has well-defined rules for specifying the order in which the operators in an expression are evaluated when the expression has several operators. The operators are evaluated as per their priority (or precedence).

#### Precedence Order

When two operators are having different priority, then an operator with the higher precedence is operated first. For example, in expression  $a + b * c$ , multiplication is having higher precedence than addition, so  $b * c$  is evaluated first and then the result is added to a. Thus it is as good as writing  $a + (b * c)$ . Precedence rules can be overridden by explicit parentheses. So, instead of creating confusion, use parenthesis freely.

#### Associativity

When two operators with the same precedence appear in the expression, the expression is evaluated according to its associativity. Associativity determines the direction (left-to-right or right-to-left) in which operations are performed. In most of the cases, associativity is from left to right. For unary operations and assignment, it is from right-to-left.

Table 7.4 gives the list of operators discussed in this chapter, listed in order from highest precedence (evaluated first) to lowest precedence (evaluated last):

Operations	Operators	Associativity
Unary operations	++, --, !, unary - and +, type-cast	Right-to-left
Multiplication, division, modulus	*, /, %	Left-to-right
Addition and subtraction	+, -	Left-to-right
Relational operators	<, >, <=, >=	Left-to-right
Relational operators (Equality and inequality)	==, !=	Left-to-right
Logical AND	&&	Left-to-right
Logical OR		Left-to-right
Conditional operator	?:	Right-to-left
Assignment operators	=, +=, -=, *=, /=, %=	Right-to-left

**Table 7.4 : Operators and their precedence**



For example  $x = y = z = 7$  is treated as  $x = (y = (z = 7))$ , leaving all three variables with the value 7. This is due to right-to-left associativity of assignment ( $=$ ) operator. Remember that an assignment is an operator, so assignment statement evaluates to the value on the right hand side expression. Thus, in  $x=y=z=7$ , it evaluates  $z=7$  first. This assigns value 7 to variable  $z$  and value of expression  $z=7$  is also 7, which is making the expression as  $x=y=7$ .

On the other hand,  $72 / 2 / 3$  is treated as  $(72 / 2) / 3$  since the  $/$  operator has left-to-right associativity. It is to be noted that there is no explicit operator precedence table in the Java Language Specification and different tables on the Web and in textbooks disagree in some minor ways.

## Control Structures

In general, the statements are executed sequentially, one by one. Sometimes, program logic needs to change the flow of this sequence. The statements that enable to control the flow of execution are considered as control structures.

There are two types of control structures: loops and branches. Loops are used to repeat a sequence of statements over and over until some condition occurs. Branches are used to choose among two or more possible courses of action, so also called selective structure.

In Java, control structures that are used to determine the normal flow of control in a program are: if statement, switch statement, while loop, do..while loop and for loop. Each of these structures is considered to be a single statement, may be a block statement.

## Block

A block statement is a group of statements enclosed between a pair of braces, "{" and "}".

The format of a block is:

```
{  
    <statements>  
}
```

Block can be used for various purposes as follows :

- To group a sequence of statements into a unit that is to be treated as a single statement, usually in control structures. (will be discussed soon)
- To group logically related statements.
- To create variables with local scope for statements within a block.

For example,

```
{ // This block exchanges the values of x and y  
    int temp;    // temporary variable for use in this block only  
    temp = x;    // save a copy of x in temp  
    x = y;       // copy y into x  
    y = temp;    // copy temp into y  
}
```

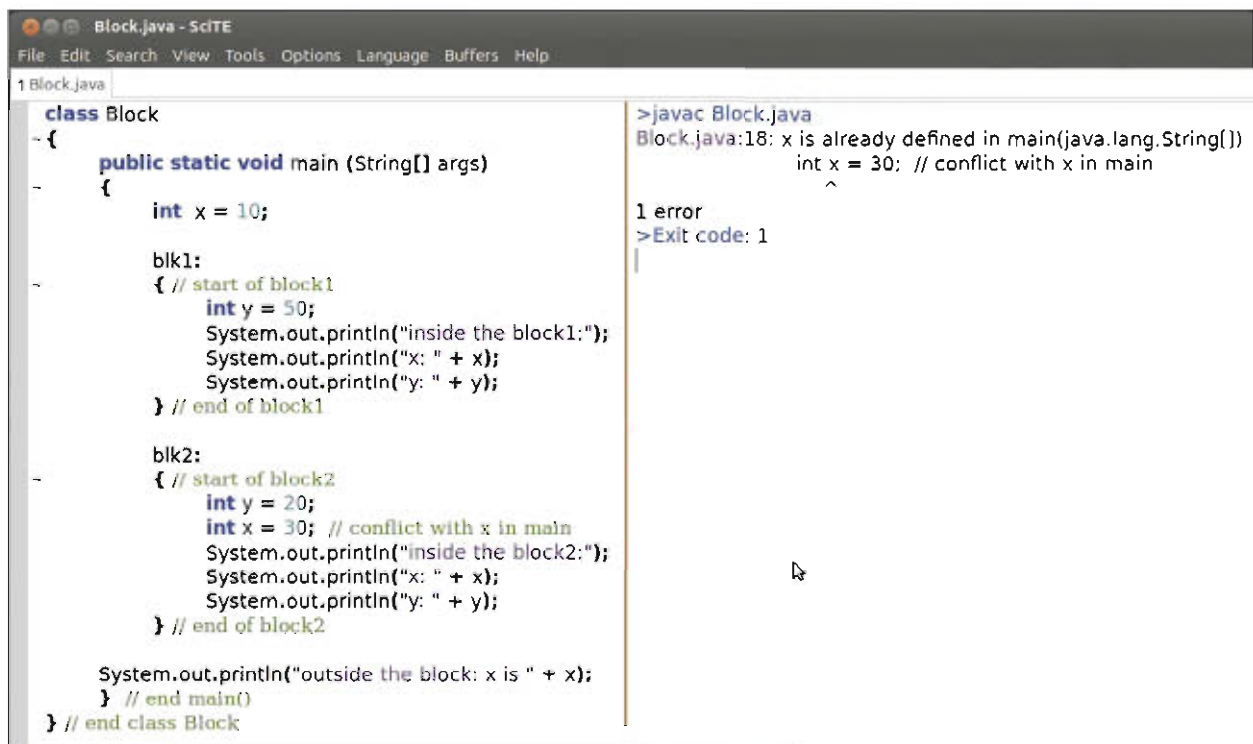
When we declare variables inside a block, they are local in that block and such variables will cease to exist after the block. We cannot use temp outside the block in which it is declared.

A variable declared inside a block is completely inaccessible and invisible from outside that block. When the variable declaration statement is executed, memory is allocated to hold the value of the variable. When the block ends, that memory is released and is made available for reuse. The variable is said to be local to the block.

There is a general concept called the "scope" of a variable. The scope of a variable is the part of the program in which that variable is valid. The scope of a variable defined inside a block is limited to that block only.

When we try to declare a variable with the same name as of the variable in scope, there will be an error. See code listing and the result shown in figure 7.10. Here, we have used labelled block only for better understanding. It is not must to use in the given example. We will see the use of labelled block later in this chapter.

In code listing shown in figure 7.10, we have tried to declare variable x in block labelled blk2. Block blk2 is in the scope of main method block. Variable x that is declared in the block of main method is also having its scope in blk2. Thus, declaring variable x in blk2 conflicts with variable x in the scope of main method block and compiler shows an error.



```
class Block
{
    public static void main (String[] args)
    {
        int x = 10;

        blk1:
        { // start of block1
            int y = 50;
            System.out.println("inside the block1:");
            System.out.println("x: " + x);
            System.out.println("y: " + y);
        } // end of block1

        blk2:
        { // start of block2
            int y = 20;
            int x = 30; // conflict with x in main
            System.out.println("inside the block2:");
            System.out.println("x: " + x);
            System.out.println("y: " + y);
        } // end of block2

        System.out.println("outside the block: x is " + x);
    } // end main()
} // end class Block
```

```
>javac Block.java
Block.java:18: x is already defined in main(java.lang.String[])
    int x = 30; // conflict with x in main
            ^
1 error
>Exit code: 1
```

**Figure 7.10 : Conflicting variable names in the same scope**

Figure 7.11 shows the modified code. Here variable x is declared in the scope of entire main method. As blk1 and blk2 are in the same block, x is available in blk1 and blk2 as well. Variable y declared in labelled block blk1 ceases to exist outside that block. After execution of blk1, variable y is discarded. In blk2, when variable y is declared, it may be allocated any memory location from available memory. If we do not initialize value of variable y in blk2, it will return an error when we refer it in blk2.

This means that variable `y` of `blk2` has nothing to do with variable `y` of `blk1`. Actually variable `y` of `blk1` is not accessible in `blk2`.

```

class Block
{
    public static void main (String[] args)
    {
        int x = 10;

        blk1:
        { // start of block1
            int y = 50;
            System.out.println("inside the block1:");
            System.out.println("x: " + x);
            System.out.println("y: " + y);
        } // end of block1

        blk2:
        { // start of block2
            int y = 20;
            //int x = 30; // conflict with x in main
            System.out.println("inside the block2:");
            System.out.println("x: " + x);
            System.out.println("y: " + y);
        } // end of block2

        System.out.println("outside the block: x is " + x);
    } // end main()
} // end class Block
  
```

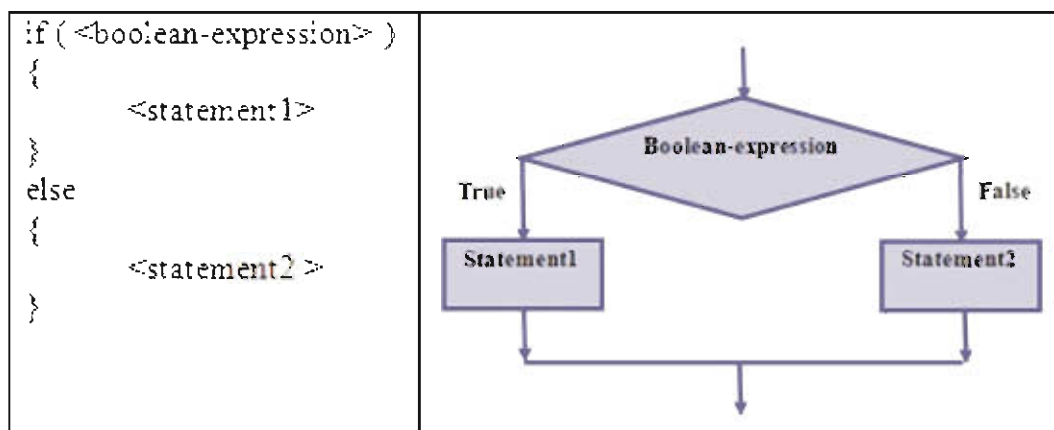
```

> javac Block.java
> Exit code: 0
> java -cp . Block
inside the block1:
x: 10
y: 50
inside the block2:
x: 10
y: 20
outside the block: x is 10
> Exit code: 0
  
```

**Figure 7.11 : Program showing scope of variable**

### if Statement

The if statement when used in a program enables to take one of two alternative courses of action, depending on whether the value of a given boolean-valued expression is true or false. It is an example of a "branching" or "decision" or "selective" control structure. The form if statement is as shown in figure 7.12.



**Figure 7.12 : Structure of if statement**

When if statement is executed, it first evaluates boolean expression. If its value is true, it executes `statement1` (all statements in a block); otherwise it executes a block of statements written after keyword `else`. `<statement>` in if statement is usually a block statement. It may be any single statement, but

it is advisable to use block to make it easy to insert other statements later. Refer following code snippet that uses if statement to determine whether an integer is even or odd.

```
if ( x%2 == 0 ) // assume int x
{ // divisible by 2
    System.out.print(x);
    System.out.println (" is even");
}
else
{ // not divisible by 2
System.out.println (x + " is odd");
}
```

Keyword else and a block after else are optional. So, if statement can be without else part as shown in the following form:

```
if ( <boolean-expression> )
{
    <statement1>
}
```

When an if statement is used in another if statement, it is called nested-if statement. See following example which determines grade based on marks obtained.

```
if ( marks >= 70 ) // int marks
{ grade = 'A';      // char grade
}
else
{
    if (marks >= 60)
        grade = 'B';
    else if (marks >= 50)
        grade = 'C';
    else
        grade = 'F';
}
```

Let us consider one more example of nested-if statement.

```
if ( x > 0 )
    if (y > 0)
        System.out.println("both x and y are greater than zero");
else
    System.out.println("x <= 0");
```



Here, it seems that the else part is corresponding to "if (x > 0)" statement, but actually it is attached to "if (y > 0)", which is closer. Thus it is executing the true part of (x>0).

If we want to attach else to "if (x>0)", we should enclose the nested if in a block as shown here.

```
if ( x > 0 )
{
    if (y > 0)
        System.out.println("both x and y are greater than zero");
}
else
    System.out.println("x <= 0");
```

### Switch Statement

A switch statement is used when there are many alternative actions to be taken depending upon the value of a variable or expression. Here, the result of the test expression must be of the type taking discrete values. The form of switch statement is shown below :

```
switch (<expression>)
{
    case <constant-1>:
        <statements-1>
        break;
    case <constant-2>:
        <statements-2>
        break;

    // more such cases

    case <constant-n>:
        <statements-n>
        break;

    default:
        <statements-n1>
}
```

In the switch statement, the test expression should be of the type byte, char, short or int. It can also be of enum data type (not discussed here).

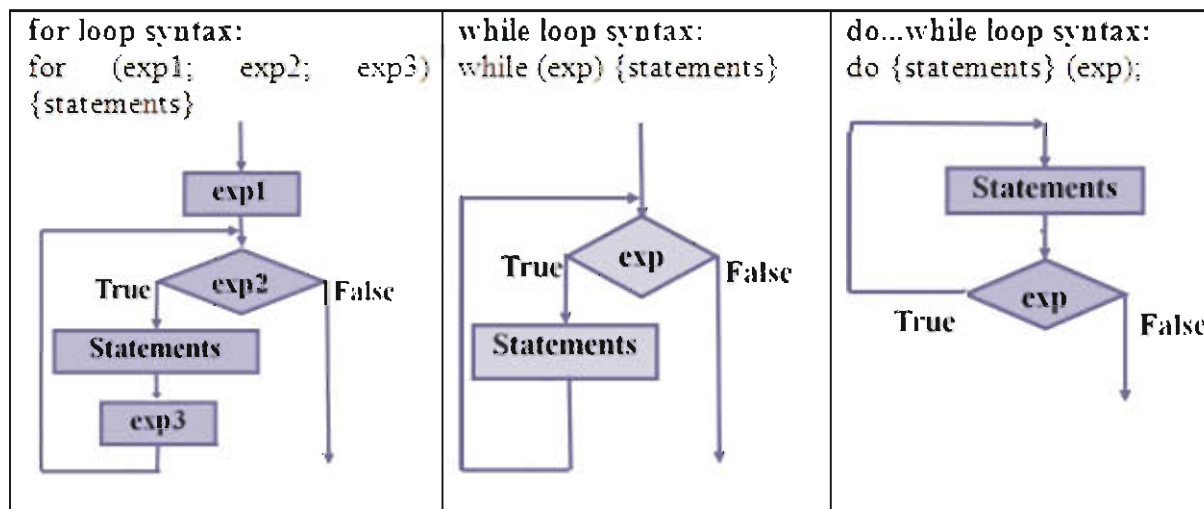
When executing switch statement, the value of the test expression is compared with each of the case values in turn from case1 onwards. If a match is found, the respective case statements (not necessarily a block) are executed. If no match is found, the default statement is executed. The default

is optional, so if there is no match in any of the cases and default doesn't exist, the switch statement completes without doing anything.

Note that break statement used after each case is not mandatory. Use of break statement is to break the switch statement, i.e. to jump at the first statement after the end of switch.

### Repetitive control structures

Java supports three types of looping constructs: for, while and do...while. Figure 7.13 shows the syntax and structure of all these loops.



**Figure 7.13 : Repetitive Control Structures**

In for and while loop, test expression is evaluated first and the statements in the loop are executed if condition is true. These loops are entry-controlled or pre-test loop constructs. Here, it is possible that statements in a loop are not executed at all.

When number of iterations are pre-determined, usually for loop is used. In this loop, all the three expressions are optional. First expression is initializer, second expression is condition and third expression is an iterator. Thus for(;;) is valid; but requires some control statements to break the loop. If break statement is not executed, it will result in infinite loop.

In do...while loop, it evaluates the test expression after executing the statements in a loop. It repeats the loop if the test condition is true. Thus, do...while loop is exit-controlled or post-test loop construct. Here, statements of loop are executed at least once.

Following examples print integer values from 0 to 9 using all the three loop constructs.

Use of for loop :

```
for (int i = 0; i < 10; i++)
{
    System.out.println(i);
}
```

Use of while loop :

```
int i = 0;
```

```
while(i < 10)
{
    System.out.println(i++); //prints i before applying i++
}
```

Use of do...while loop :

```
int i = 0;
do
{
    System.out.println(i++);
} while(i < 10);
```

### Use of break and continue statement

The break statement is used to transfer the control outside switch or loop structure.

When break is used in switch structure, it skips all the following statements and control is transferred at the first statement after the end of switch statement.

In a loop, break statement is used to exit the loop. When break is executed in a loop, all the following statements in a body of the loop are skipped and no further iteration takes place. The control is transferred at the first statement after the end of loop structure. Remember that break jumps outside the nearest loop containing this statement.

Use of continue statement is used to skip the following statements in a loop and continue with the next iteration.

Both the statements break and continue are used the same way as in C language.

### Nested loops

Loops of same or different types can be nested in Java. Figure 7.14 shows the use of nested loops, break and continue statement.

```

class prime // determine prime numbers in the range 3 to 100
{
    public static void main (String[] s)
    {
        boolean prime;
        int i, last, n;

        System.out.println ("Prime numbers between 3 and 100:");
        for (n=3; n<100; n=n+2) // no need to try even numbers > 2
        {
            if ( n < 4)
            {
                prime=true;
                System.out.println(n);
                continue;
            }

            //if (n%2 == 0) prime = false;
            prime=true;
            i=3; last = (int)Math.sqrt(n);
            do
            {
                if (n%i == 0) // n is divisible by i
                {
                    prime=false;
                    break; // break innermost do...while loop???
                }
                i = i + 2; // no need to divide by even numbers
            } while (prime && (i<last)); // end of do...while loop
            if (prime) System.out.println (n);
        } // end of for loop
    } // end of main
} // end of class

```

Terminal Output:

```

> javac prime.java
> Exit code: 0
> java -cp . prime
Prime numbers between 3 and 100:
3
5
7
11
13
17
19
23
25
29
31
35
37
41
43
47
49
53
59
61
67
71
73
79
83
89
97
> Exit code: 0

```

Figure 7.14 : Use of nested loops, break and continue statements

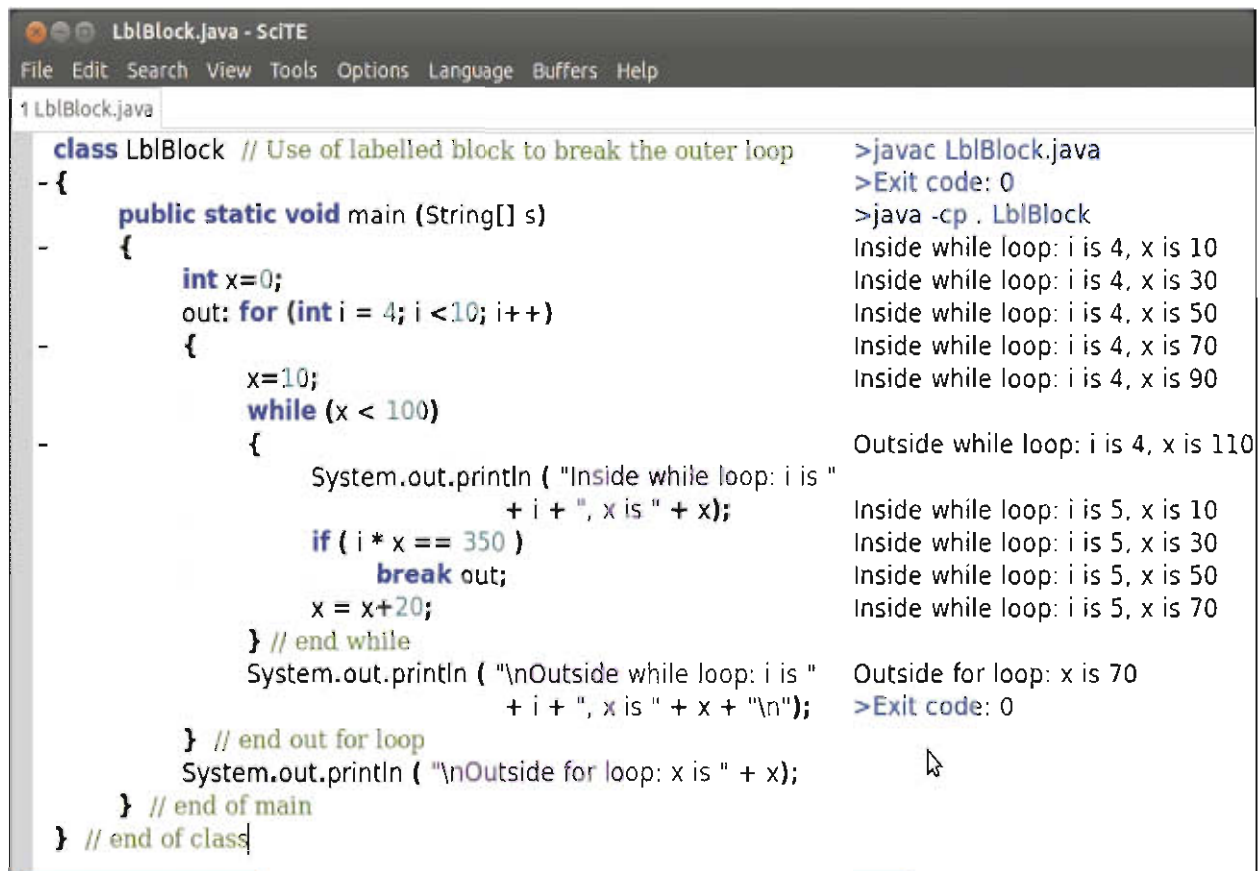
In figure 7.14 we have written a program that prints prime numbers between 3 and 100. Additionally, it also shows the use of sqrt function. The Java class libraries include a class called Math. The Math class defines a whole set of math operations. Function sqrt() is one of the static method member of the class Math and is invoked as Math.sqrt().

### Labelled loops and labelled break

When we use nested loops, break statement breaks the nearest enclosing loop and transfers the control outside the loop. Similarly continue also restart the enclosing loop.

If we want to control which loop to break and which loop to reiterate, we can use labelled loop. To use a labelled loop, add the label followed by colon (:) before the loop. Then, add the name of the label after the keyword break or continue to transfer control elsewhere other than enclosing loop. Figure 7.15 shows a program that uses labelled loops.

When code in figure 7.15 is executed, the value of  $i \times x$  is 350 when  $i=5$  and  $x = 70$ . As the if condition in while loop is evaluated to true, it executes 'break out;' statement. This will terminate the outer for loop labelled as 'out'. If only break statement would have used, it would have exited an enclosing while loop and continued with next iteration in for loop. Here, it does not execute outer for loop for  $i=6$  onwards.



```

class LblBlock // Use of labelled block to break the outer loop
- {
-     public static void main (String[] s)
-     {
-         int x=0;
-         out: for (int i = 4; i < 10; i++)
-         {
-             x=10;
-             while (x < 100)
-             {
-                 System.out.println ( "Inside while loop: i is "
-                                     + i + ", x is " + x);
-                 if ( i * x == 350 )
-                     break out;
-                 x = x+20;
-             } // end while
-             System.out.println ( "\nOutside while loop: i is "
-                                 + i + ", x is " + x + "\n");
-         } // end out for loop
-         System.out.println ( "\nOutside for loop: x is " + x);
-     } // end of main
- } // end of class
  
```

```

> javac LblBlock.java
> Exit code: 0
> java -cp . LblBlock
Inside while loop: i is 4, x is 10
Inside while loop: i is 4, x is 30
Inside while loop: i is 4, x is 50
Inside while loop: i is 4, x is 70
Inside while loop: i is 4, x is 90
Outside while loop: i is 4, x is 110
Inside while loop: i is 5, x is 10
Inside while loop: i is 5, x is 30
Inside while loop: i is 5, x is 50
Inside while loop: i is 5, x is 70
Outside for loop: x is 70
> Exit code: 0
  
```

Figure 7.15 : Use of labelled loop and labelled break

Let us consider another example of labelled loop and labelled break in a program that stops execution when first odd non-prime number in the range 40 to 100 appears. See figure 7.16.

```

class LblLoop // determine first non-prime odd number in the range 41 to 100
{
    public static void main (String[] s)
    {
        boolean prime=true;
        int i, last, n;

        // break the loops as soon as first non-prime odd number is found
        forLoop: for (n=41; n<100; n=n+2) // no need to try even numbers >2
        {
            if ( n < 4)
            {
                prime=true;
                System.out.println(n);
                continue;
            }

            prime=true;
            i=3; last = (int)Math.sqrt(n);
            do
            {
                if (n%i == 0) // n is divisible by i
                {
                    prime=false;
                    break forLoop; // break for loop labelled 'forLoop'
                }
                i = i + 2; // no need to divide by even numbers
            } while (prime && (i<last)); // end of do...while loop
            if (prime) System.out.println (n + " is prime");
        } // end of for loop
        if (!prime) System.out.println (n + " is not prime");
    } // end of main
} // end of class

```

```

>javac LblLoop.java
>Exit code: 0
>java -cp . LblLoop
41 is prime
43 is prime
45 is not prime
>Exit code: 0

```

**Figure 7.16 : Program to print prime number between 40 and 100**

### Summary

In this chapter, we have discussed about the basics of Java. There are eight basic data types supported in Java. Character in Java is a 2-byte Unicode character. Various types of literals can be used in Java. By default, numeric literal is assumed to be of the type double. Control structures like if, switch, for loop, while loop and do...while loop are very similar as in C language. Block can be specified by enclosing the statements in a pair of curly braces { }. Scope of variables is in the block where they are defined.

### EXERCISE

1. What is the size of character data type in Java ?
2. Write the number of bytes taken by int and long data types in Java.
3. Explain if and switch statement available in Java.
4. Discuss about various repetitive structures available in Java.
5. How can one use labels for a block or loop in Java ?



6. Choose the most appropriate option from those given below :

(1) How many basic (primitive) data types are supported in Java ?

- (a) 2                      (b) 4                      (c) 8                      (d) 16

(2) What is the default data type of floating point literal ?

- (a) int                      (b) long                      (c) float                      (d) double

(3) Which character set is used for char data type in Java ?

- (a) Unicode                      (b) ASCII                      (c) EBCDIC                      (d) All of these

(4) Which of the following is compiled error free ?

- (a) `for(;;){int i=7};`                      (b) `while (1){int i=7};`  
(c) `while (True){int i=7};`                      (d) All of these

(5) Which of the following is not allowed as first character in valid variable name ?

- (a) Underscore ( \_ )                      (b) Digit                      (c) Letter                      (d) Dollar ( \$ )

(6) Which of the following is not a basic data type in Java ?

- (a) char                      (b) long                      (c) byte                      (d) String

(7) What is the default value of boolean type data ?

- (a) null                      (b) true                      (c) false                      (d) 0

(8) What will be the result of arithmetic expression  $7/2$  ?

- (a) 3                      (b) 3.5                      (c) 1                      (d) 0

(9) What will be the result of arithmetic expression  $-7\%2$  ?

- (a) -3                      (b) -1                      (c) 1                      (d) -3.5


(10) What will be the result of arithmetic expression  $-7.5\%2$  ?

- (a) -3                      (b) -1.5                      (c) 1.5                      (d) Error

### LABORATORY EXERCISE

Write a Java program for the following :

1. During a sale at a store, a 10% discount is applied to purchases over Rs. 5000. Write a program that assigns any value to variable 'purchase' and then calculates the discounted price. Display purchase amount and discount offered.

- 
2. Write a program that determines the price of a movie ticket based on customer's age and the time of the show (normal or matinee). The normal show and matinee show ticket price for adult is Rs. 100 and Rs. 50 respectively. Adults are those over 13 years. The children's ticket price is Rs. 60 and Rs. 40 for normal show and matinee show respectively. Declare variables of suitable data types for age and show time, assign the values to these variables and print age, show time and the ticket price.
  3. Write a program to display the grade based on percentage of marks using switch statement.
  4. A bank gives loan to customers at a simple interest of 12% per annum. Interest for the whole term is charged at the beginning. Compute the monthly installments considering the term of 36 months for loan amount of Rs. 10000, 20000, 30000, 40000, 50000, 60000, 70000, 80000, 90000 and 100000.
  5. Write a program that prints square root of integer numbers starting from 5 till the square root is at 50 or less.
- 